IL 10-2000-011
In Reply Refer To: 112D

October 10, 2000

UNDER SECRETARY FOR HEALTH'S INFORMATION LETTER

DENTAL UNIT WATERLINES

1. The Office of Dentistry (112D), Office of Occupational Health (136), Office of Infectious Diseases (111A), and the Office of Occupational Safety and Health (00S1) have jointly developed this Information Letter in conjunction with the Chief Network Office (10N) to address concerns over potential bacterial hazards associated with biofilm in dental unit waterlines. Several cases of infectious disease have been attributed to dental unit water exposure among patients and workers (see Att. C, subparas. 1a and 1i). Nevertheless, systematic attempts to identify such disease following standard public health approaches have failed to confirm this hazard (see Att. C, subpara. 1m). Markers of exposure suggest that dental personnel are exposed to potentially infectious agents in the work place (see Att. C, subparas. 1d, 1f, and 1o). While dental treatment water may pose a public health threat, traditional approaches to public health hazard assessment do not support that this is a common problem. Nevertheless, water containing high numbers of microorganisms poses a theoretical risk to dental staff members and to patients who are medically or immuno-compromised, or have underlying lung disease (see Att. C, subpara. 1q). Recently, media stories have alerted the public to this issue. In 1995, the American Dental Association (ADA) Board of Trustees highlighted this issue by publishing recommended actions.

2. Attachment A outlines the scientific background information on bacterial colonization of dental unit waterlines; Attachment B suggests a possible set of actions that field sites might consider regarding concerns over potential bacterial hazards associated with biofilm in dental unit waterlines; Attachment C contains a list of pertinent publications and Internet resources, and Attachment D contains reference information concerning protocols, exposure, issues and significant findings.

3. Clinical questions may be referred to C. Richard Buchanan, DMD, FICD, at (202) 273-8503. Questions about surveillance, linkage strategies, or further scientific work, may be referred to either Gary Roselle, M.D., Chief Consultant in Infectious Disease, at (513) 475-6398; or Michael Hodgson, M.D., MPH, Director, Occupational Health Program, at (202) 273-8579. Questions regarding general safety and health issues may be referred to Arnold B. Bierenbaum, Director, Safety and Technical Services in the Veterans Health Administration (202) 273-5841 or Frank Denny, Industrial Hygienist, Office of Occupational Safety and Health (202) 273-9745.

Thomas L. Garthwaite, M.D.
Under Secretary for Health

Attachments

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ATTACHMENT A

SCIENTIFIC BACKGROUND

1. Microorganisms found in dental units largely represent common, water-borne organisms. Bacteria and some protozoa and fungi that habitually reside in the human oropharynx, skin, and lower intestine have also been isolated from dental waterline samples (see Att. C, subpara. 1q). Water stagnation and a low flow rate near tubing walls fosters the development of biofilm causing large numbers of bacteria to be found in water flowing through dental handpieces, air/water syringes and other devices used in patient care. There have been reports of as many as 100,000 colony-forming units per milliliter (CFU / ml) of water in newly-installed dental lines within five days of operation and an excess of 1,000,000 CFU / ml of water in older lines. Common contaminants include species of Pseudomonas, Legionella, non-tuberculous Mycobacterium, Klebsiella, Moraxella, Flavobacterium, and Escherichia. In addition, oral flora such as Lactobacillus, Streptococcus, Actinomyces, Staphylococcus, Bacterioides, Veillonella and Candida have been recovered from dental treatment water.

2. The American Dental Association (ADA)-recommended goal of less than 200 CFU / ml at any point in time represents an engineering limit. It is directed to manufacturers of dental units to encourage the development of equipment that is less conducive to biofilm formation. It is not aimed at practicing dentists and is not meant as a ceiling level for practitioners.

3. Measurement of bacterial levels in waterlines can be misleading in the absence of a formal plan for sample collection and interpretation. Measuring bacteria levels in the waterlines without applying a disinfection protocol is likely to confirm the presence of "high" numbers of bacteria. The Environmental Protection Agency's (EPA) standard for safe drinking water of no more than 500 CFU / ml of aerobic, mesophilic, and heterotrophic bacteria is a poor measure of associated health risk (see Att. C, subparas. 1b and 1c). For this reason, the measurement of bacteria levels in the waterlines to indicate water quality is not useful. Because microorganisms multiply rapidly in water, reliance on quantitative sampling may be misleading unless sampling occurs very frequently. Sampling may be useful, however, when conducted as a periodic, planned check on adherence to a regimen of disinfection procedures as indicated by the manufacturer of the equipment in use.

4. An alternative approach to control focuses on defining appropriate maintenance strategies rather than on meeting "criteria levels." This approach has been taken by a number of professional organizations and defines the expected standard of practice.

a. The Department of Defense United States Air Force (USAF) has published guidelines, "Year 2000 USAF Dental Infection Control Guidelines." Methods suggested by the USAF, and by the American Dental Association (ADA), are able to reduce biofilm levels. Summaries of those methods are attached.

b. The 1993 Recommendations for Infection Control in Dentistry, from the Centers for Disease Control and Prevention (CDC), and incorporated by the ADA, as well as by the Organization for Safety and Asepsis Procedures (OSAP), proposed the use of sterile irrigating solutions for all dental procedures involving the cutting of bone. These recommendations represent a clearly-defined, expected level of practice. These procedures also include the

following guidelines: installing and maintaining manufacturer approved anti-retraction valves; flushing the lines and handpieces for a minimum of 20 to 30 seconds between patients; and allowing waterlines to run for several minutes at the beginning of each clinic day with the handpieces removed. Sterilized handpieces and sterile or disposable syringe tips should be installed after each flushing. ***NOTE:*** *These procedures are intended to aid in physically flushing out patient material that may have entered the turbine and air or waterlines.*

5. Currently, the California (CA) State Dental Board regulates infection control practices. The requirements include daily flushing of the lines before seeing patients, flushing between patients, developing a written protocol, and posting a copy of the regulation in a conspicuous location (see CA Board of Dental Examiners, 1994).

6. The Occupational Safety and Health Administration (OSHA) inspection procedures require Food and Drug Administration (FDA)-approved point-of-use filters of 0.2 micron pore size in the event of complaints or illness related to legionella potentially associated with dental unit waterlines (see Att. C, subpara. 1l).

7. Despite the lack of clear scientific evidence for a need to act, justification for addressing the phenomenon of biofilm and dental water quality can be found in current best practices in dentistry, infection control, and the informed consent of patients. Reasonable procedures should be followed to keep bacterial counts in dental waterlines as low as reasonably achievable (see Att. C, subparas. 1m, 1n, and 1q).

8. In the event that illness may be traceable to dental treatment, the local infection control practitioner, infectious disease consultant, or employee health physician should be contacted with relevant information to develop a formal investigation.

ATTACHMENT B

SUGGESTED SET OF ACTIONS

1. According to the American Dental Association (ADA)**,** the Food and Drug Administration (FDA) has cleared over twenty-six products that improve the quality of water used in dental units, these can be found in a table at http://www.ada.org/adapco/jada/archives/9911/waterlines/table.html. These products fall into one or a combination of the following four basic categories:

a. Independent water systems that bypass the community water supply;

b. Chemical treatment protocols (intermittent or continuous);

c. Point-of-use filters; and

d. Sterile water delivery systems. ***NOTE:*** *Items a, b, and c are useful for lowering the biofilm level; however, they do not create the sterile water necessary for surgical procedures.*

NOTE: *The pros and cons of these systems are discussed in detail in the Journal of the American Dental Association (JADA) article, "ADA Council on Scientific Affairs and ADA Council on Dental Practice. Dental Unit Waterlines: Approaching the Year 2000." JADA, November 1999; 130: 1653-64.*

2. When selecting a system for reducing bacterial contamination, include the following considerations:

a. Efficacy of the system;

b. Staff time involved in utilizing and maintaining the system;

c. Staff compliance with system requirements; and

d. Cost.

3. In light of the ongoing research on this issue, it is suggested that facility Dental Services contact manufacturers of their dental units for recommendations on systems that will reduce bacterial contamination without damaging the dental units. Remaining informed of current literature is also highly recommended.

NOTE: *Quality assurance is an important aspect of any infection control process.*

4. Findings of Jorgensen, Detsch and others (see Att. C, subparas. 1g, 1h, and 1j) indicate that dental units operating on municipal water systems should be considered contaminated until measures to control biofilm are incorporated. In addition, closed water systems do not control contamination unless a disinfection protocol is followed (see Att. C, subpara. 1p). A variety of sampling methods for monitoring are available to evaluate the effectiveness of the control

program. Use of bacterial samplers, such as the Millipore 'dip stick' for assessing water quality, has been identified as an acceptable alternative to bacterial cultures -- as culturing may not be practical for use in the dental service (see Att. C, subparas. 1g and 1h). The Department of Veterans Affairs (VA) has a contract price with Millipore at $43.00 for a pack of 25 samplers; the number is GSAPROP15.

5. Services may consult their microbiology section for guidance in determining bacterial levels in the waterlines. Veterans Health Administration has an Interagency Agreement, IGA V654(90)P-97003, with the U.S. Public Health Service (PHS), Federal Occupational Health, for performing sample analysis and consultation. The Reno Veterans Integrated Service Network (VISN) Support Service Center (VSSC) coordinates the ordering and payment of PHS services. VSSC implements the PHS Interagency Agreement with VISNs paying the cost for their facilities using the PHS services. The PHS agreement offers the advantage of not requiring complicated procurement procedures to access. Marilyn Waggoner, VSSC coordinator in Temple, TX, for the PHS agreement, can be contacted at (254) 778-4811, extension 4244. The PHS contact is Michelle Stemmons, Federal Occupational Health, Chicago, IL, at (312) 886-0413, extension 11.

ATTACHMENT C

REFERENCES

1. Publications

a. Atlas, R., Jeffrey, F., and Huntington, M. Legionella Contamination of Dental Unit Waters. Applied and Environmental Microbiology, 61, (4), 1995:1208 – 1213.

b. Barbeau, J., Nadeau, C. "Dental Unit Waterline Microbiology: A Cautionary Tale." Canadian Dental Association, 1997:775 – 779.

c. Batik, O., Craun, G., Pipes, W. (1983). Routine Coliform Monitoring and Waterborne Disease Outbreaks. Journal of Environmental Health, 45, 227 – 230.

d. Clark, A. (1974). Bacterial Colonization of Dental Units and the Nasal Flora of Dental Personnel. Proceedings of the Royal Society of Medicine, 67, 1269 – 1270.

e. Infection Control Regulations: 1005. Minimum Standards for Infection Control. California Board of Dental Examiners. 1994.

f. Fotos, P., Westfall, I., Snyder, R., Miller, R., Mutchler, B. "Prevalence of Legionella-specific IgG and IgM Antibody in a Dental Clinic Population." Journal of Dental Research, 64, (12), 1985:1382 – 1385.

g. Jorgensen, M., Detsch, S., Wolinsky, L. "Disinfection and Monitoring of Dental Unit Waterlines." General Dentistry, 1999:152 – 156.

h. Karpay, R., Plamondon, T., Mills, S., Dove, B. "Combining Periodic and Continuous Sodium Hypochlorite Treatment." Journal of the American Dental Association, 1999: 957 – 965.

i. Martin, M. (1987). The Significance of the Bacterial Contamination of Dental Unit Water Systems. British Dental Journal. 1987: 163, 152 – 154.

j. Micik, R., Miller, R., Mazzarella, M., Ryge, G. "Studies on Dental Aerobiology: I. Bacterial Aerosols Generated During Dental Procedures." Journal of Dental Research, 1968: 48, (1), 49 – 56.

j. Mills, S. (1998). "The Waterline Controversy: Politics or Principles?" OSAP Report, 11, (1), 6.

k. Muraca, P, Stout, J., Yu, V., Yee, Y. "Legionnaires' Disease in the Work Environment: Implications for Environmental Health." American Industrial Hygiene Journal, 49, 1998: 584 – 590.

l. Occupational Safety and Health Administration (OSHA) Technical Manual, TED 1 – 0.15A, 1999, U.S. Department of Labor.

m. Oppenheim, B., Sefton, A., Gill, O., Tyler, J., O'Mahony, M., Richards, J., Dennis, P., Harrison, T. (1987). "Widespread Legionella pneumophila Contamination of Dental Stations in a Dental School Without Apparent Human Infection." Epidemiology of Infection, 99, 159 – 166.

n. Pankhurst, C., Johnson, N., Woods, R. "Microbial contamination of Dental Unit Waterlines: The Scientific Argument." International Dental Journal, 1998: 48, 359 – 368.

o. Reinthaler, F., Mascher, F., Stunzer, D. "Serological Examinations for Antibodies Against Legionella Species in Dental Personnel." Journal of Dental Research, 1998: 67,(6), 942 – 943.

p. Williams, H., Kelley, J., Folineo, D., Willliams, G., Hawley, C., Sibiski, J. "Assessing Microbial Contamination in Clean Water Dental Units and Compliance with Disinfection Protocol." Journal of the American Dental Association, 125, 1994:1205 – 1211.

q. Williams, J., Molinari, J., Andrews, N. "Microbial Contamination of Dental Unit Waterlines: Origins and Characteristics." Compendium. 17, (6), 1996: 538 – 558.

2. Internet Resources

a. American Dental Association, Statement on Dental Unit Waterlines, 1995: http://www.ada.org/prac/position/lines.html

b. Centers for Disease Control and Prevention. Recommended Infection-Control Practices for Dentistry, 1993, MMWR42 (RR-8)
http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00021095.htm

c. Center for Biofilm Engineering, Montana State University, Interdisciplinary Glossary, 1999, http://www.erc.montana.edu/Res-Lib99-SW/glossary/Gterms.html

d. Environmental Protection Agency, National Primary Drinking Water Regulations, 1999, http://www.epa.gov/OGWDW/wot/appa.html

e. Occupational Safety and Health Administration. OSHA Technical Manual, TED 1-0.15A, 1999. http://www.osha-slc.gov/dts/osta/otm/otm_toc.html

f. Organization for Safety & Asepsis Procedures. Issue focus: Dental Unit Waterlines, 1999, http://www.osap.org/water/index.html

g. The Journal of the American Dental Association (JADA) article titled, “Dental Unit Waterlines: Approaching the Year 2000” by the ADA Council on Scientific Affairs, JADA, Vol.130, November 1999, p.p. 1653-1664, http://www.ada.org/adapco/jada/archives/9911/waterlines/water.html – includes table referenced in the Letter.

h. USAF Dental Investigation Service (DIS) “Dental Waterline Treatment Protocol,” http://www.brooks.af.mil/dis/

ATTACHMENT D

Protocols

	Karpay et al. 1999	*Year 2000 USAF Dental IC Guidelines Dental Water Quality Chapter 10*	*Jorgensen & Detsch 1998*		*Unpublished Data: Dr. Janet Stout (focus: Legionella control not biofilm)*	*OSHA Technical Manual 1999*	*CDC IC Practices for Dentistry 1993*	*New Products*
Separate Water System	**X**	**X**	**X**					
Double Bottle	**Unspecified**	**Unspecified**	**Recommend**					
Single Bottle								
Air bypass	**X**	**X**	**X**					
Disposable plastic syringe								
Water Source								
Municipal	**1 gtt Cl in 750 ml (3 ppm Cl)**	**BOIL OR 1 gtt Cl in 750 ml water (3 ppm Cl)**	**Never use tap water, re: total dissolved solids and development of resistant strains.** (*Discussion, T Caruthers, Steve Detsch 4/20/00)		**X**			
Lab conditions- soften, rechlorinate	**X**							
Sterile water		**X or**	***5 ppm Cl (3 gtt / L)**		**X or**		**Surgical**	
Sterile saline							**Surgical**	
Distilled		**X or**	***5 ppm Cl (3 gtt / L)**		**X or**			
Boiled		**X or**						

	Karpay et al. 1999	*Year 2000 USAF Dental IC Guidelines Dental Water Quality Chapter 10*	*Jorgensen & Detsch 1998*		*Unpublished Data: Dr. Janet Stout (focus: Legionella control not biofilm)*	*OSHA Technical Manual 1999*	*CDC IC Practices for Dentistry 1993*	*New Products*
Chemical Agents	**X**	**X**	**X**		**X**			
Bleach	**1:10 daily for 5 days then weekly**	**1:10 wkly**	**1 :10 wkly till no growth**		**1 :10 wkly (Monday a.m.)**			
Glutaraldehyde								
Iodophor								
Chlorhexidine			*Personal discussion					
Microfiltration		**Optional Point of use (no effect on biofilm)**			**Point-of-use filter at heating unit**	**Point- of-use, 0.22 micron pore size**		
Water Heating Units	**no**	**no**	**no**		**Bypass tubing for bleach treatment**			
Air Purge, Dry Overnight	**X**	**X**	**X**					
Flush Lines	**x**	**X**	**x**				**X**	
Morning	**X**	**2-3 minutes**					**several min. & remove handpieces**	
Between Patients	**Standard Practice**	**20-30 seconds**					**20-30 sec - thru handpieces**	
End of day	**X**	**3 minutes**	**x**					
Disinfect oral cavity	**X**		***Personal discussion**					

	Karpay et al. 1999	*Year 2000 USAF Dental IC Guidelines Dental Water Quality Chapter 10*	*Jorgensen & Detsch 1998*		*Unpublished Data: Dr. Janet Stout (focus: Legionella control not biofilm)*	*OSHA Technical Manual 1999*	*CDC IC Practices for Dentistry 1993*	*New Products*
Antiretraction Valves		**Proper Maintenance**					**Proper Maintenance**	
Monitoring		**Periodic**	**Daily till neg. then weekly**		**Twice weekly - Tues & Friday**			
SBA								
R2A								
Millipre Dip Sticks	**q Fri**		**Suggest**					
Contact Manufacturer	**X**	**X**	**X**		**X**	FDA Cleared	**X**	
Handpieces	**Air Purge**	**"Universal Sterilization"**					**Sterilize**	

Exposure

Reference	*YR*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*		
Legionella									
Atlas, Williams, et al., Appl & Env. Microbiol, 1995, 61, 1208-13	1995	Legionella Contamination of Dental-Unit Waters	Legionella Prevalence: Comparison of local water/ DUW / biofilm	Source of Legionella Exposure in Dental units	**Ref:** death of dentist - Leg. traced to office DUWL; reports of sero-positive dental workers	Legionella concentration is higher in DUWL than domestic potable water	Legionella source: DUWL (not hand tools)	Higher Legionella levels may be result of PCR detection methods vs. viable-culture methods	
						Lack of clinical association with DUWL as source of Legionella	Dental exposure - unrecognized element of medical Hx. of certain cases		
Oppenheim, Sefton, et al., Epidem Inf, 1987, 99, 159-66.	1987	Widespread Legionella pneumophila contamination of dental stations in a dental school without apparent human infection	Case finding, environmental survey, Case-control study, review of national surveillance data	Discover human infection; extent & source of L. pneumophila after 3 of 5 dental water samples were positive, reports of debris in DUWL, & increased resp. ill in staff & students	Legionella pneumonia after exposure to legionella-contaminated aerosols.	No cases traced to dental clinic, no difference in sero-positivity of controls vs. staff & students			

Reference	*YR*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*		
Reinthaler, Mascher, et al. J. Dent Res 1988, 67, 942-943	1988	Serological Examinations for Antibodies against Legionella Species in Dental Personnel	Case-control for antibodies to L. pneumophila from dental workers	Identify Legionella infection risk factors & modes of transmission		Sero-positivity to Legionella	Sero-positive: 36(34%) dental workers, five (5%) controls	Positive – 1.5 yrs-minimum	Highest prevalence in Dentists with constant exposure to high-speed drill & spray aerosols
Fotos, Westfall, et al., J Dent Res, 1985, 64, 1382-85		Prevalence of Legionella-Specific IgG & IgM Antibody in a Dental Clinic Population	Case-control study - serum samples of 270 dental personnel compared to random sample of non-clinic group	To understand importance of Legionella infection in the dental clinic	Legionella pneumonia after exposure to legionella-contaminated aerosols.	Responders had greater than 2 years clinical exposure time	IgM & IgA markers should be considered		
LEGIONELLA: MODES OF TRANSMISSION									
Blatt, Parkinson, et al. Am J Med, 1993, 95, 16-22	1993	Nosocomial Legionnaires' Disease: Aspiration as a Primary Mode of Acquisition	Case-control and environmental exposure	Identify Legionnella infection risk factors & modes of transmission during an outbreak of nosocomial Legionnaires' Disease	Aspiration acquired nosocomial pneumonia post oropharynx colonization	Water supply pipe renovations taking place	**Significant Medical History:** immunosuppressive therapy; **Significant Hospital Exposure:** *bedbaths, NG tubes, antibiotic therapy *(not - using shower)		

Reference	YR	Title	Study type	Purpose	Health Effects of Concern	Significant Findings	Significant Findings		
Brabenderr, Hinthorn, Asher, et al.,JAMA, 1983, 250, 3091-92	1983	Legionella pneumophila Wound Infection	Case Study: Wound infection traced to Hubbard tank treatments in hospital	Investigate extrapulmonary cases of L pneumophila infection	Infection or colonization of wounds with L pneumophila	Implications for treatment of decubitus ulcers, burns, other open wounds	Providone Iodine disinfection of tank ineffective Hyperchlorination & superheating of warm water supplies suggested		
Muder, Yu, Woo, Arch Intern Med, 1986, 146, 1607-1612	1986	Mode of Transmission of Legionella pneumophila: A Critical Review	**Theory Overview:** L. pneumophila modes of transmission	Directions for future epidemiological research	Aerosolization: (1968) Pontiac fever - hypersensitivity reaction to organism (1976) Legionnaires' pneumonia	Natural variation of disease over time. Outbreaks terminate spontaneously without intervention: leads to lapses in surveillance; biased interpretation of mode of transmission			

Reference	*YR*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*		
Non-tuberculosis mycobacterium (NTM)									
Schulze-Robbecke, Feldmann,Tuberculе & Lung Dis, 1995, 76, 318-23	1995	Dental units: an environmental study of sources of potentially pathogenic mycobacterium	NTM Prevalence: Comparison of local water / DUW / biofilm	NTM Transmission: Identify situations of relevant contact with NTM	Pulmonary & Cutaneous disease Lymphadenitis, Disseminated infection	79 NTM strains isolated from 43 water & 16 biofilm samples, DUWL NTM concentration-400 X drinking water. Biofilm: 1165 cfu / cm2	Concern that determinants of infection are present: large quantities of infectious agent, portal of entry; third element: susceptible host	**Ref:** NTM disease-with assoc. dental tx: post prosthetic heart valve infection; post dental extraction-2 cases cervical lymphadenitis	
					Research needed to determine association with dental tx & infection / colonization with NTM			**Ref:** NTM aerosolize - 95% oral bacteria from mouth by water sprays and air turbines - droplet size <5Um	

Reference	*YR*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*		
Adherent Bacteria in DUWL									
Downey, Rosen, J Dent Res., (IADR Abstra+A2cts #3177) 1996, 75, 415		Adherent Bacterial in DUWLs	Isolate and identify bacteria using types of dental tubing.	**Findings:** Bacillus licheniformis, Staphylococcus aureus, Pseudomonas sp**.**	**Conclusion:** "Certain adherent bacteria in DUWLs are pathogenic (e.g. Staphylococcus aureus)"				
Investigations									
Cuthbertson, J of CA St Dental Assn, 1954, 30, 159-160		Causes of Death Among Dentists: A Comparison with the General Male Population	Comparison of causes of death among dentists / general male population 25-65 year old.	Examine excess mortality among dentists	Check for increased cause of death associated with providing dental service	No association made	Both groups: #1#2 COD 1. Circulatory 2. Neoplasms		
Clark, 1974, Proc. R. Soc. Med, 67, 1269-30		Bacterial Colonization of DUs & the Nasal Flora of Dental Personnel	Culture of DUs and anterior nares of dentists & assistants	Examine colonization of nasal flora by DU aerosols		14 out of 30 dentists had altered nasal flora; 3 of 29 assistants	Organisms: Pseudomonas spp, Proteus spp, P. Aeruginosa, P. cepacia	Suggest: microfiltra-tion, disinfectant reservoir	"...impossible to justify spraying large numbers of bacteria into an operative field"

Due Diligence

Reference	*Yr*		*Title*	*Study Type*	*Purpose*	*Concerns*	*Significant Findings*	*Significant Findings*	
Year 2000 USAF Dental Infection Control Guidelines		http://www.brooks.af.mil/dis/icguidelines/attach4.htm		See Protocol section					
Organization for Safety & Asepsis Procedures (OSAP) March, 2000			Position Paper: Dental Unit Waterlines		Statement of the Responsibilities of Clinicians	Lack of epidemiological evidence of illness / injury in pts / staff is NOT valid rational for inaction	**RECOMMENDATIONS** 1. Review literature, understand potential risks. 2. Follow manufacturer recommendations for maintaining quality treatment water 3. When replacing dental units & devices, select products that maintain water quality. 4. Obtain manufacturer's info on safety, efficacy, and cost effect of products.		**RECOMMEND Bacterial counts as low as reasonably achievable**
OSHA Technical Manual, TED 1-0.15A, 1999	1997	**OSHA Tech Manual http://www.osha-slc.gov/dts/osta/otm/otm_iii/otm_iii_7.html**			OSHA Inspection Procedures: Point-of-use filter 0.22 micron pore size				
ADA Statement on DUWL, 1995	1995	**ADA http://www.ada.org/prac/position/lines.html**			Propose research into feasible methods to reduce bacteria in DUWL	**Recommended Goal**: <200 CFU/ml aerobic mesophilic heterotrophic bacteria (ceiling level) by year 2000	**Suggested Practices:** *Independent reservoirs; *chemical disinfection; *daily draining & air purging; *point of use filters; *simple test methods		
Dental Board of California, 1994	1994	**Reg. Section 1005 http://www.comda.ca.gov/infcontrol.html**			Minimum standards for Infection Control	**Requirements:** Autoclave handpieces; anti-retraction valves; Flush between patients	**Requirements:** Purge with air or water for 2 minutes at beginning of each day	**Requirements:** Written program	

Reference	*Yr*		*Title*	*Study Type*	*Purpose*	*Concerns*	*Significant Findings*	*Significant Findings*	
MMWR, 1993, 42 (No. RR-8):1-12 Centers for Disease Control & Prevention (CDC)		**Recommendations for Infection Control in Dentistry http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00021095.htm**				**Recommendation** Sterile irrigating solutions for all surgical procedures involving cutting of bone.	(See Protocol Section)		
Table of FDA-Cleared Devices for DUWL		http://www.osap.org/water/wl-fda.htm							
McCarthy, Koval, MacDonald AJIC, 1999, 27, 377-384	2000		Compliance with recommended infection control procedures among Canadian dentists: Results of a national survey	Mailed survey, stratified random sample of 6537 dentists (66.4% response rate)	**"Excellent compliance"** routine use of 18 recommended IC procedures (ADA, CDC, CDA) **Finding: 6% compliance**	Transmission of BBP & drug resistant microorganisms	50% use extra IC with HIV, HBV patients: vulnerable to discrimination charges	Most important predictor of compliance: attending IC course in last 2 yrs.	
				Relevant Results:	**Flush waterlines: 55%**	**Heat-Sterilize Handpieces: 94% - after each patient 77%**			
Kono, Dentistry Today, 1997, Aug, 32-41	1999		DUWL, Taking the High Road	Review Summary	Outline key information	Prevent infection; cross contamination; biofilm			

Reference	*Yr*		*Title*	*Study Type*	*Purpose*	*Concerns*	*Significant Findings*	*Significant Findings*	
Barbeau,Gauthier, Payment, Canadian J. Microbiol, 1997, 63, 775-779	1997	Biofilms, infectious agents, & DUWL: a review	Review Summary	Outline need for solutions; litigation claims of illness from DUWL	Aging, hi risk population, opportunistic infection	Pseudomonas: 90% of cultivable bacteria - 500 - 200 cfu/ml – significant. risk	Biofilm increases biocide resistance 1000 times, selects, protects potentially harmful bacteria	Total bacteria count - poor indicator, inadequate measure of health risk.	

Ancillary

Reference	*Year*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
Leenstra, Joris, et al., Oral Surg. Oral Med Oral Path, 1996, 82, 637-43		Oral endotoxin in healthy adults	Case-Control Study	Establish a baseline of oral endotoxin in a healthy group	Assess mechanisms of oral carriage of Aerobic gram-negative bacilli (AGNB)	Assess benefits of low endotoxicity of anaerobic gram-negative flora.	1 mg of anaerobic endotoxin per ml of undiluted saliva was found	Endotoxin likely generated by indigenous anaerobic gram-negative bacilli carried in the oropharynx.	
High Speed Dental Handpieces									
Martin, Br. Den J, 1998, 184 (6) 278-9	1998	The Air Water Syringe (AWS): A Potential Source of Microbial Contamination	A guide explaining problems; evaluating extent; pt outcomes; solutions			Disposable AWS tips are preferable; cover body of syringe with plastic; or disinfect	Impossible to clean, need vacuum autoclave		
Martin, Br. Den J, 1994, 177 (2) 48	1994	Cross Infection Guidelines	Editorial Comment	"Risks should not be negligible but nil"	**ref:** cross infection with blood borne viral disease	Cross-infection control mandates sterilized instruments & barrier techniques			

Reference	*Year*	*Title*	*Study Type*	*Purpose*	*Health Effects of Concern*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
Epstein, Sibau et al., JADA, 126, 87-92	1995	Assessing Viral Retention and Elimination in Rotary Dental Instruments	5 handpieces using lab model herpes simplex virus - handpieces run in HSV culture medium	Surface & internal disinfection will inactivate HSV		Untreated Handpieces - viral recovery from all	External wipe with glut & alc: viral recovery from 3 out of 5 hand pieces.	No viral recovery with surface wipe & internal glutaraldehyde flush	Viral recovery with surface wipe & internal saline flush
Lewis, Boe, J Clin Microbiol, 1992, 30, 401-406	1954	Cross-Infection Risks Associated with Current Procedures for Using High-speed Dental Handpieces	Dilution rates of material from handpieces	**REF:** Handpiece contamination by patient pathogen-containing materials/ viruses	Transmission of blood borne pathogens, - analagous to percutaneous needle exposure	Absence of cross-infection cases in dentistry due to lack of adequate detection - not universal application of adequate infection control	Significant cross-infection potential exists if only external disinfection is applied	**Recommend:** thorough cleaning & heat treating between patients as component of universal precautions	
Scheid, Kim et al., JADA, 1982, 105, 658-660	1983	Reduction of microbes in hand pieces by flushing before use	Collection & culture of aerosol samples from dental hand pieces & tubing after several flushing protocols.	Identify the effect of flushing on reducing the microflora in aerosol mist	**Ref:** reports of respiratory illness twice as great for dental than pharmacy & med students.	Flushing DUWL before attaching handpiece - then flushing handpiece with 100 ml water reduces bacterial CFUs in aerosols			

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Prosthetic Joints & Oral Health									
Martin, Br Dent J, 1995, 178 (3) 92	1995	Oral Heatlh & implanted joint prostheses	editorial comment		Orally-derived infection of implanted prosthesis - rare AND preventable	Treat oral infection before joint replacements, & monitor oral health indefinitely.			
Bartzokas, Johnson et al., 1994, BMJ, 309, 20-27	1994	Relation between mouth & haematogenous infection in total joint replacements	Analysis of 4 prosthetic joint infections with case records; microbial exam of isolates from mouth & prostheses; mouth examination for caries, & disease	Confirm oral sepsis as a source of BB infection of prosthetic joints		**Each patient:** same strain of S sanguis in mouth & infected prosthesis; severe caries / periodontal disease	**Conclusion:** Treat oral sepsis before joint replacement & maintain oral health		

Interventions

Reference	*YR*	*Title*	*Study Type*	*Objectives*	*Issues*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
Karpay, Plamondon, Mills, Dove, JADA, 1999, Jul, 130, 957-965		Combining Periodic & Continuous Sodium Hypochlorite Treatment to Control Biofilms in Dental Unit Water Systems	Prospective Study of 10 DUs	*Evaluate continuous (3ppm Cl) & intermittent (5000-ppm Cl) DUWL treatment *Assay Trihalomethanes (THM) in DU water	EPA Trihalomethane (THM) drinking water standard: 100 ppb	Weekly tx with 1:10 NaClO and continuous 3 ppm Cl in water maintains fewer that 200 CFU/ml				
Jorgensen, Detsch, General Dentistry, 1999, Apr, 152-156		Disinfection and monitoring of DUWL	Longitudinal study 15 DU evaluate disinfection protocol	**Goal: User Friendly Protocol Methods:** Baseline samples of tap water; 3-way syringes; handpiece hoses; ultrasonic scalar hoses 2 bottle system / air purge. Initial tx: 1. Air purge; 2. fill with 10%	**Key points:** *Sterile water in reservoirs for all dental procedures. Units remain air-purged when not in use.	**Protocol:** Collect random samples weekly. Air purge, fill with 1:10 bleach soln., 10 minute contact time; air purge; flush with 12 L sterile water; air purge. Continue this protocol: after 3 negative cultures (< 1 cfu/ml) Culture weekly No bleach	**(+) culture:** *bleach again, *check protocol of personnel. *Maintenance personnel check for corrosion	**Abbreviations:** >375 cfu = too numerous to count **(TNC)** Failure to show growth = **<1cfu / ml**	Scanning Electron Microscopy (SEM)-to visualize physical nature of biofilm before and after disinfection protocol. Evaluated: Presence/ absence of bacteria. Biofilm, bacterial density, biofilm volume	SEM- 12 tap water samples: 9 = 2.0 - 23.0 cfu/ml; 3 TNC Baseline cultures: all DUWL TNC

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				Personal discussion of T Caruthers & Steven Detsch 4/20/00	**3 gtt NaOCl per L sterile water prevents development of resistant organisms; need 5ppm to have kill**	**Important to have low total dissolved solids (TDS)**	**Purchase a TDS meter and pool test kit to check chlorine**			
						Results: 12 of 15 Dental Units: Sharp drop in bacterial contamination after initial HCl treatment in 3 wks - <1 cfu / ml	**Results:** SEM of WL tubing - very little bacteria Biofilm detected	**Results:** 12 units - Discontinue weekly bleach after 3 consec. neg. cultures. Excellent protocol compliance	**Results**: No deleterious effects on internal components	Once disinfection achieved - use of sterile water in closed system, air-purging lines, maintaining lines - dry - when not in use - prevented increase in effluent bacteria counts.
Barbeau, Gauthier, Payment, Canadian J. Microbiol, 1997, 63, 775-779	1997	Biofilms, infectious agents, & DUWL: a review	Review Summary	Outline imperative of prevention; need for solutions, litigation claims of illness from DUWL	Aging, hi risk population, opportunistic infection	Pseudomonas may be 90% of cultivable bacteria - 500 - 200 cfu/ml - significant risk	Biofilm increases biocide resistance 1000 times, selects, protects potentially harmful bacteria	Total bacteria count - poor indicator of health risk. Inadequate measure of health risk		
Clappison, Oral Health, 1997, June, 11-15	1997	Priority One: Decon-tamination of DUWL	Review Summary	Outlines need to improve DUWL quality	Provider/ patient protection	Biocides; follow protocol; periodic microbiologic water testing	Disinfect DUWL and upgrade respiratory protection	Closed systems, functioning anti-retraction valves		

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Santiago, Huntington, Johnston et al., General Dent, 1994, Nov/Dec, 528-535	1994	Microbial contamination of DUWL: Short- & long-term effects of flushing	Comparison of bacterial contamination levels at various times before / after flushing and static periods	Analyze DUWL flora; sample timing; procedural effects; flushing; stasis. Medical / aesthetic questions of dispensing poor-quality water in health care setting. Limit bacteria in ac	Pathogens, common opportunistic microorganisms flourish in biofilm. Dental / medical equipment, catheters, drainage tubes, pacemakers, artificial hearts, joints	More variation during workday than overnight stasis. Hemolytic staph. & strep. in lines from sterile water: pt derived	8 of 89 DUWL met standards for potable water; overnight samples - mid range of other collection times - need further study of dynamics of bacterial production	SEM DUWL lumens: cocci; bacilli; spirilla. TEM of line sections - amebic trophozoites; cysts; nematode worms	Flushing - transient reduction; may cause increase; 30 min after flushing - increased levels - biofilm remains in tact, generates more bacteria	
Mayo, Brown, Am J Dent, 1999, 12, 256-260	1999	Effect of in-line bacteriological filters on numbers of heterotrophic bacteria in water emitted from non-autoclavable dental air-water syringes	Comparative study of in-line filter placement with non-autoclavible AWS	Measure effectiveness of in-line filters to reduce bacteria counts	Prevent opportunistic infections, oral infections, health care worker exposure to contaminated aerosols	Need to verify manufacturers' claims- filters effective whole day -with autoclavable AWS. Biofilm Gram-negative rods produce endotoxin - >> measure endotoxin levels in filtered & unfiltered DUW	Unfiltered AWS water > unacceptable; in-line filter close to AWS reduce heterotrophic bacteria by 97% - but still unacceptable	Conclude that filtered water is re-contaminated during passage through tubing & valves in the non-autoclavable AWS	Filtration alone will not provide water of acceptable quality. Autoclavable AWS becoming available	

Reference	*YR*	*Title*	*Study Type*	*Objectives*	*Issues*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
Karpay, Plamondon, Mills, Dove, JADA, 1998, Feb, 129, 207-211	1998	Validation of an in-office DUW Monitoring Technique	Comparative study of three microbial testing methods	Determine sensitivity, specificity & accuracy of HPC Samplers compared to R2A agar & HPC agar used to monitor DU with separate water reservoirs & having weekly treatment with sodium hypochlorite 1:10	Dental offices lack microbiol skills. Lack of standard evaluation methods for DUW - problematic in comparing results	Monitor compliance routinely - dependent on practice size, staff, previous results, eqt./technique changes.	DUWL colonization is universal with municipal water or separate system. Remediation - conscientious compliance with interventions	Assure effectiveness of treatment protocols and verify compliance with manufacturer-recommendations with in-office monitoring devices	HPC samplers (Millipore) compare favorably with R2A agar & HPC agar - accuracy rate 92.6%. Considered user-friendly, economical	
Shearer, JADA, 1996,127, 181-189		Biofilm and the Dental Office	Overview of biofilm formation, ADA statement	Suggestions for improving water quality in dental offices	**Ref:** Documented reports of waterborne disease outbreaks - pathogens: P. aeruginosa, E. coli, L species, Crypto-sporidium Speculation - seroprevrates for L antibodies in Dental personnel - may reflect continuous exposure	Concern: Numbers of dental pts with diminished resistance to overt & opportunistic microbial pathogens Concern: Awareness of potential occupational hazards	**Interim Recommenda-tions:** Waterlines without handpieces - discharge water several min. at beginning of each day note - see Santiago, this recommendation does not improve DUW quality	High-speed handpieces - run minimum 20-30 seconds after use on each patient to flush patient material that may have entered turbine, airlines, waterlines. Use enclosed container to minim spray, splatter & aerosols	Follow instructions of manufacturer for maintenance of waterlines	Commercial options to improve water quality - consider with caution; consult with manufacturer

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							Use sterile saline /water with surgical procedures -- cutting of bone	ADA is develop evaluate guidelines for eqt. to control biofilm - Assoc.'s Acceptance program		
Puttaiah, Wills et al., J Dent Res (IADR Abstracts)75, 1996		A Multi-Group Longitudinal Study of DUWL Contamination	Longitudinal study of 5 groups of waterlines using an automated device simulating DUWL. Identification of control methods	Describe contamination (heterotrophic bacterial counts) in outflow water over 8 weekly measurements	**Conclusion:** Outflow water from groups using filter combinations showed minimal or no contamination All other groups showed contamination unacceptable for dental care over time.	**Minimal to no growth**: (0.00-0.39 log CFU/ml) Group 2 - municipal water-filter changed daily	**Unacceptable growth**: (1.18 - 4.12 log CFU/ml) Group 1 - sterile water; Group 4 - municipal water flushed wkly - NaOCl; Group 5 - Tap water only			
						Group 3 - municipal water, filter changed daily, weekly bleach flush				

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Plamondon, Mills et al., J Dent Res (IADR Abstracts)75, 1996		Effects of Bleach on Mature Biofilm in DUWL	Case-control study of DUWL	To determine if DUWLs in biofilm colonized units could be decontamination using a manufacturer-recommended protocol	**Conclusion:** Data suggest - may be possible to dramatically reduce planktonic bacteria in biofilm-colonized DU by treating lines q wk with 1:10 bleach solution & dry overnight	**12 DUs:** initially municipal water, modified with separate reservoir systems to add sterile water & disinfectants. 3 groups: 1 control, 2 experimental	Baseline Range 5.6x105-1.06x106 cfu/ml Controls - sterile water Grp 1 - 5.25 NaOCl 1:110 Grp 2 - dilute 1:100	Treatments: q wk - Heterotrophic plate count prior to tx, air purge, test solution - 10 min in line, then flush with 500 ml sterile distilled water, air-purge, dry overnight	Results: Controls - 1.21 log reduction in CFU/ML Results: Treated units - 1:10 NaOCl --(4.23 log reduction) 0 - 80 CFU/ml 1:100 NaOCl- (3.02 log reduction) 30 - 6.1x102 CFU/ml	
Williams, Johnston et al., JADA,1993, Oct, 124, 59-65		Microbial Contamination of DUWL: Prevalence, Intensity & Microbiological Characteristics	Survey of DUWL : 150 operatories, 54 sites - NW USA - 116 3-way syringe lines, 54 hi-speed handpieces, 12 scalier lines	**Goal -** collect water representative of that issuing from instruments during typical procedures. Report on scope of contamination and profile of microbial population.	Hi numbers of types of bacteria found - impart foul odors, bad taste & texture commonly associated with dental operatory water. Effects of flushing - ephemeral	72% DUWL - "unfit for human consumption" (ref 500 cfu/ml-US Army) 28 DUWL samples = too few to count (TFC) 1 of 11 faucet - unfit 9 faucet samples TFC	Mean heterotrophic cfu counts were: 49,700 (SD=156200); max 1,200,000 /ml 3-way syringe; 72500 (SD 140,300) max 550,000 /ml hi-speed handpiece	12 scalars (mean 19,800 cfu/ml, SD=37,300)	No trends - types/models DU or degree contamination., geograph sites, collection / shipping	In-situ view of biofilm - proliferation/release of bacteria sometimes in clumps - 30 - 50 u thick, not penetrating plastic wall

Reference	*YR*	*Title*	*Study Type*	*Objectives*	*Issues*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
				Conclusion: work to be done investigating any relationship of organisms in DUWL to medical complications after dental care. Organisms in DUWL must be considered along with concern re handpiece steriliz. & infection control practices in dental off	Ultraclean water supply alone negated with biofilm in lines Pseodomonas cepacia, resp. path of cystic fibrosis pts, proliferates in distilled water: 100,000cfu/mL in hrs	Microorganisms in mature biofilm - notoriously resistant to chemical disinfection.	Sterilization of handpieces reduces risk of pt to pt transfer but sterile instrumentation become heavily contamination with bacteria (some pt-derived) when connect to DUWL.			
Meiller, DePaola et al., 1999, Jan, JADA, 130, 66-72		DUWL: Biofilms, Disinfection & Recurrence	Series of trials using various biocides: Bleach (B); Glutaraldehyde (G); Isopropanol 15.3% (I)	To examine the effects of biocides on biofilm and the recurrence of microbial growth after treating DUWLs.	**Concern:** transmission of microbial pathogens to patients from biofilm in DUWL. Concern: biocide residual may be trapped in biofilm matrix presenting additional toxic risk to patients.	Agents reduce microorganisms in effluent water but do not destroy biofilm matrix even with periodic treatments. Recoloniz. occurs rapidly.	No evidence of resistance development during the study. Concern that lon-term treatments may yield resistant strains or mutations.	Effluent with B or I - to pretreatment level by day six & 15. G recurrence by day three.		

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				Conclusion: need disinfectant * that reduces viable bacteria below culturable levels, * disrupts/removes biofilm and * poses no toxicity risks to pts	Be wary of products not including results of independent tests related to antimicrobial efficacy, biofiilm disruption, toxicity.					
Miller, RDH, 1996, 16 (5) 36-38		Elimination of contaminants in waterlines may be guesswork, but several options help	Procedures to eliminate DUWL contamination	Methods under investigation to protect patients. Suggest PPE and respiratory protection for workers	CDC recommendations - sterile water/saline for surgical procedures, flush handpieces 20-30 sec with air & water between patients. Caution - flushing does not eliminate biofilm	**Alternative water source -** require cleaning & flushing with disinfectant rinsing. **Disposable plastic syringes** prefilled with approp. tx water - used for hand irrigation	**Concern** with corrosion of DUWL fittings, handpieces, hazard to pt. if lines not rinsed**.**	Replacing DUWL does not prevent biofilm. Filters may remove bacteria. System is available for insertion into DUWL before water enters handpiece or 3-way syringe.	Filters do not affect bio film. Small particles not retained	Rubber dam reduces patient contact with DUW.

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Murdoch-Kinch, Andrews et al., 1997, Sept, JADA, 128, 1235-1243		Comparison of DW Quality Management procedures	Longitudinal study - 4 DU in dental school clinic - using several DW management procedures	Investigate whether DUWL contamination can be controlled with available technology and adherence to protocols	Evaluate 4 DUWL contamination controls identified by **ADA:** Independent water reservoir; chemical tx regimens; daily draining & purging; point-of-use-filters.	Importance of Maintenance, Separate Water Supply; Follow manufac's protocol	Microbial population on DUWL reduced with 0.2um filters at point of use	SEM: DUWL of new unit (4) with no filters, adherence to recommendations - changing supplied bottled water, flushing and purging lines, disinfecting on schedule can result in minimal biofilm for at least 2 mos.	Plasticizers in new lines may exert temporary antimicrobial effect	Maintenance protocols for SWS - time, care, proper handling of corrosive chemicals, training, consistent compliance with protocol
		***SWS-separate water supply; *MWS-municipal water**	**U1** old unit, *SWS	**25 day Scanning Electron Microscopy (SEM) Assay:** Biofilm, planktonic populations	**58 day SEM Assay** Biofilm, various microbial forms				Units had pinch valves; no metal valves; no corrosion problems	Must manage water source
			U2 new unit, *SWS, filter at handpiece, & AWS	Trace adherent organisms	No biofilm, occasional microorganisms on inner walls				Control unit - substantial biofilm remained - more aggressive antimicrobial treatment needed to clear water lines of existing biofilm - or new waterlines to improve predictability and efficacy of water management protocols	Filters may be problematic: Cost; inventory maintenance; following replacement protocol; may use tap water in error

Reference	*YR*	*Title*	*Study Type*	*Objectives*	*Issues*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*	*Significant Findings*
			U3 new unit, *MWS, filter at handpiece no at AWS	Planktonic, no adherent accumulations	Filter limited biofilm growth at handpiece. AWS heavy biofilm					
			U4 new unit, *SWS, no filters	Trace adherent organisms, no biofilm	No biofilm					
Dayoub, Rusilko, Gross, J Periodon, 1978, 49, 261-265	1978	A Method of Decontamination of Ultrasonic Scalers & High Speed Handpieces		Eliminate microflora in dental handpiece water spray to prevent wound contamination		0.2 um pore size filter unacceptably restricted flow	Need systems with easily changed disposable filters using tubing resistant to deterioration by steam or chemical sterilization	Lacks durability for daily use.		
Blake, Br Den J, 1963, Nov, 413-415		The Incidence and Control of Bacterial Infection in Dental Spray Reservoirs	Bacterial counts on dental instruments, control measures	Bacterial control in spray fluid, tubes & spray heads; prevent blocking spray jets, pleasant flavor, effective / not detrimental to tissues or react with metal parts	Organisms of concern: Klebsiella aerogenes, Bacillus subtilis, Pseudomonas pyocyanea	Control methods: 1:5,000 chlorhexidine in tap water - no growth after 2 days use	Control methods: 1:10000 chlorhexidine no growth in 7 days (topped off without emptying) 3 months - no growth in any bottles or sprays.	Conclusion: 1:5000 to 1:10000 chlorhexidine in tap water controlled bacterial growth. Flavoring added to enhance taste	Chlorhexidine Gluconate Solution B.P. in 20% solution - a convenient supply to prepare dilute solution - uses distilled water to avoid precipitation with chlorine.	

Marais, Brozel, Brit Dent J, 1999, 187, 154-158	1999	Electro-chemically activated (ECA) water in DUWL	Comparative study of ECA and distilled water in microbial control of DUWL	Investigate use of electro-chemically activated (ECA) water to treat biofilm in DUWL	Concern: Iatrogenic transmission of pathogens: risk of disease / death; litigation & adverse publicity	ECA treatment results in colony counts of <1CFU/mL.	ECA is highly microbicidal; water / saline fed into a special unit - activates the water - - meta-stable state of water - free radicals produced	Similar technology is in place in developing countries for drinking water purification.		